

EXECUTIVE SUMMARY

SHARING OF THE 1675-1710 MHZ BAND BY METEOROLOGICAL SATELLITE, METEOROLOGICAL AIDS AND LOW EARTH ORBIT MOBILE SATELLITE SYSTEMS

At the recently completed WARC, the frequency band 1675-1710 MHz was allocated in Region 2 to the Mobile Satellite Service (MSS). This allocation is in the Earth-to-space direction on a co-primary basis. Operation of MSS systems in this band is contingent upon the ability to share the band with other co-primary services. These services are Meteorological Aids (METAID), Meteorological Satellite (METSAT) in the space-to-Earth direction, Fixed and Mobile (except aeronautical mobile).

The METAID allocation is 1660-1700 MHz and is used for transmission from airborne transmitters to terrestrial receiving stations.

The METSAT allocation is from 1670-1710 MHz and is used for space-to-Earth transmission. The METSAT allocation is presently being used by both Low Earth Orbit (LEO) and Geosynchronous Orbit (GSO) METSAT systems. GSO-METSAT's are presently utilizing the lower portion of the band from 1670 MHz up to approximately 1695 MHz. The LEO-METSAT's use the upper portion of the band from approximately 1695 to 1710 MHz.

This study shows that sharing is possible between Low Earth Orbit Mobile Satellite Service (LEO-MSS) and the Meteorological Satellite Service (METSAT) and Meteorological Aids Service (METAID).

Sharing of the spectrum is postulated by the establishment of a "protection zone" around the METSAT and METAID receiving terminals. MSS Earth terminals would be precluded from transmitting from within the "protection zone" on frequencies that would cause harmful interference.

The locations and characteristics of the METSAT and METAID terminals are known. The MSS terminals are relatively few in number and have a position location capability. When an MSS terminal is in the vicinity of a METSAT or METAID terminal, it, or the MSS system central control, will determine its type, frequency and time of operation, protection zone area, and assign or use frequencies that will not cause harmful interference to the METSAT or METAID terminal.

One class of METSAT terminal, the WEFAX (WEather FAXimile) terminals, would not have protection zones. There are simply too many and their location may not be known. The 200 kHz band centered on 1691.0 MHz would not be used by the MSS terminals. Considering that the MSS band allocation is 35 MHz, a 200 khz exclusion is very small.

An important sharing criteria is not to constrain the development of the METSAT and METAID services. Since the applied for LEO-MSS communications systems require positive central control, any changes to METSAT or METAID systems may be readily coordinated so as not to cause constraints on system development and still have the usage by the LEO-MSS systems.

SHARING OF THE 1675-1710 MHZ BAND BY METEOROLOGICAL SATELLITE, METEOROLOGICAL AIDS AND LOW EARTH ORBIT MOBILE SATELLITE SYSTEMS

1. INTRODUCTION

At the recently completed WARC, the frequency band 1675-1710 MHz was allocated in Region 2 to the Mobile Satellite Service (MSS). This allocation is in the Earth-to-space direction on a co-primary basis. Operation of MSS systems in this band is contingent upon the ability to share the band with other co-primary services¹. These services are Meteorological Aids (METAID), Meteorological Satellite (METSAT) in the space-to-Earth direction, Fixed and Mobile (except aeronautical mobile).

Figure 1 shows the ITU frequency allocations for each of these services. The METAID allocation is 1660-1700 MHz and is used for transmission from airborne transmitters to terrestrial receiving stations. The METSAT allocation is from 1670-1710 MHz and is used for space-to-Earth transmission.

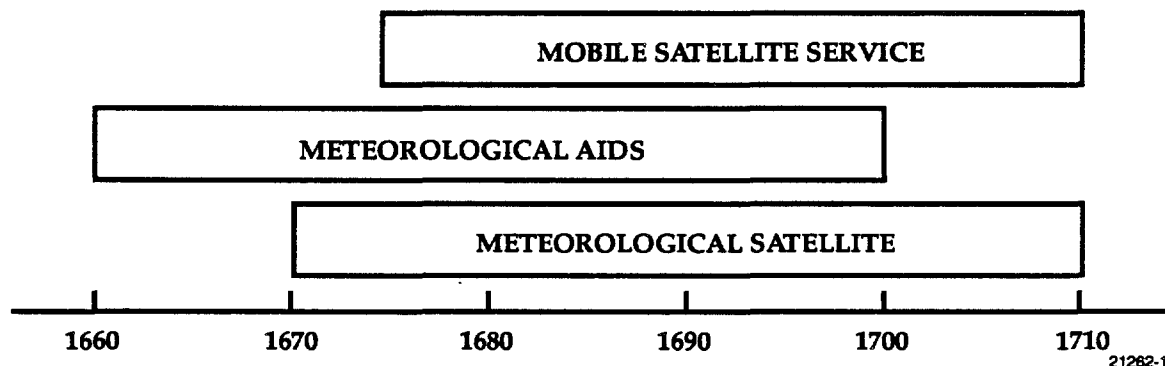


Figure 1 - Frequency Allocations

The METSAT allocation is presently being used by both Low Earth Orbit (LEO) and Geosynchronous Orbit (GSO) METSAT systems. GSO-METSAT's are presently utilizing the lower portion of the band from 1670 MHz up to approximately 1698 MHz. The LEO-METSAT's use the upper portion of the band from approximately 1698 to 1710 MHz.

This study shows that sharing is possible between Low Earth Orbit Mobile Satellite Service (LEO-MSS) and the Meteorological Satellite Service (METSAT) and Meteorological Aids Service (METAID).

¹Footnote 735A: In the band 1675-1710 MHz, stations in the mobile-satellite service shall not cause harmful interference to, nor constrain the development of, the meteorological-satellite and meteorological aids services (see Resolution COM4/X) and the use of this band shall be subject to the provisions of Resolution COM5/8

2. LEO-MSS SERVICE

2.1 General

The LEO-MSS systems are a relatively new concept in mobile satellite communications. In 1990, Motorola (IRIDIUM) and Ellipo (ELLIPSAT) filed for licences to construct and operate this type of system. In 1991, additional licenses were filed for the GLOBALSTAR, ODYSSEY, and the ARIES systems.

The LEO-MSS terminals may be characterized in the following manner:

1. Relatively few in number:

LEO-MSS are relatively thin route systems. Typically, the user terminal density would be less than one terminal in a thousand square mile area in the United States. This is an important consideration in the sharing analysis that follows. It would be difficult for high density systems, like cellular or some of the new Personal Communication Systems (PCS) to share these frequencies.

2. Mobile but their position is known

Each of the systems that were applied for in the United States includes a position location capability. This again is important in the sharing scenario since each system has the capability to control transmissions in "protection zones" around METSAT and METAID stations to prevent harmful interference to these stations.

3. Generally used for remote area communications

In addition to being thin route or low density communication systems, they are generally used for remote area communications. In areas that are covered by terrestrial cellular telephony, cellular will generally be the communication media of choice. In areas without cellular, the LEO-MSS systems would be used. The majority of the receiving terminals, for the METSAT and METAID systems, are in urban or suburban areas.

4. Communication with a central authority

LEO-MSS systems are generally in communication with a central authority that is used for control of the systems' operation including terminal transmission access to the network. Communication with a central authority is necessary for the type of sharing defined in this paper. Using updated information on the METSAT and METAID terminals that require protection, the LEO-MSS central authority would be able to control use of the frequencies by LEO-MSS terminals.

5. Low power terminals

LEO-MSS terminals generally have low transmitter powers and low gain antennas. In almost all cases, the EIRP is on the order of 15 watts or less.

2.2 Characteristics

The characteristics of various LEO-MSS mobile Earth stations are shown in Table 1. These characteristics were determined from their system applications. Only the characteristics important for sharing analyses are included. It is assumed that all LEO-MSS mobile Earth stations employ non-directional antennas.

The frequency band, 1675-1710 MHz, is allocated for Earth-to-space usage. Since the IRIDIUM system presently operates bi-directionally (transmits and receives in the same frequency band), it will not be considered here.

TABLE 1
LEO-MSS TRANSMITTER CHARACTERISTICS

SYSTEM	TRANSMITTER POWER-dBW	BANDWIDTH MHZ	ORBITAL ALTITUDE-KM
ELLIPSO II	11.0	1.4	2507
GLOBALSTAR B	2.0	1.25	1200
ODYSSEY	-0.1	5.0	8960
ARIES	2.1	0.0075	880

3. METSAT SERVICE

The characteristics of the METSAT service have been defined in the CCIR Report 395-5, 1121, NTIA Report 81-80 and GOES G-H Data Book (March 1986). The following description is derived from the NTIA Report.

The United States has launched a number of polar orbiting and geostationary experimental and operational meteorological satellites since 1960. Projects involving geostationary meteorological-satellites are also in progress in Europe under the auspices of the European Space Agency (ESA), in Japan and in the USSR. In addition to their specific national purposes, these meteorological-satellites contribute to the World Meteorological Organization's (WMO) WWW program.

The chief use of meteorological-satellite data is in weather forecasting. They are used in other ways also; in the study of climate, hydrology, and associated research purposes. Weather forecasts are predictions of the future state of the atmosphere and are based on a knowledge of its state shortly before a forecast is made. The errors in forecasts increase with the imperfections in knowledge of the initial state. Successful forecasts therefore, require observations of the atmosphere which are both detailed and up-to-date. Polar orbiting satellites produce global data on a time delayed basis, while geostationary satellites monitor specific regions of the Earth on a real-time basis.

Existing satellites in the Meteorological Service utilize the 1670-1710 MHz band for telemetering data from the satellites to Earth as well as relaying of processed Meteorological data.

3.1 Satellites

3.1.1 Geosynchronous Satellites

The Geostationary Operational Environment Satellite (GOES) provides day and night information on the Earth's weather by means of Earth imaging, retransmission of image data, data collection and relay from remote sensing platforms, and space environment monitoring.

The GOES satellite transmits data at L Band to three types of receiving stations: Command and Data Acquisition (CDA), Stretch VAS (SVAS), and Weather Faximile (WEFAX).

GOES G-H satellite transmissions to various receiving stations are defined in Table 2.

TABLE 2

GOES G-H SATELLITE TRANSMISSION CHARACTERISTICS

FUNCTION	FREQ-MHz	BAND WIDTH	EIRP-dBm	RECEIVING STATION
VAS	1681.6	23.2 MHz	54.4	CDA
Telemetry	1694.0	100 kHz	30.0/20.0	CDA
DCP	1694.5	400 kHz	33.0	CDA
Ranging	1687.1	8.2 MHz	7.0	CDA
SAR	1698.6	TBD	33.0	CDA
SVAS	1687.1	5.0 MHz	54.4	SVAS
WEFAX	1691.0	200 kHz	54.4	WEFAX

VAS: VAS is a weather observation sensor. The raw data at 28 Mbps is transmitted to the CDA station. It quadrature-phase-modulates a carrier signal centered at 1681.6 MHz with a nominal bandwidth of 23.2 MHz. VAS data is transmitted 20 minutes every half hour and shares this time period with Stretch VAS data.

Telemetry: A satellite telemetry baseband signal consisting of 194 kbps PCM and IRIG channel B or 70 kHz gated oscillator signal phase-modulates a carrier signal at transmit frequency of 1694 MHz with 100 kHz bandwidth.

DCP: The satellite receives Data Collection Platform (DCP) data falling within a 400 kHz bandwidth at nominal center frequency of 401.9 MHz. This data is frequency-converted, amplified and provided to the L-Band transponder for retransmission at 1694.5 to CDA station.

Ranging: The satellite receives and transmits L-Band ranging signals within 8.2 MHz bandwidth centered at 1687.1 MHz. The ranging function is transmitted for 10 minutes every half hour and only when WEFAX data is not being transmitted.

SAR: The satellite receives emergency signals from ELT or EPIRB transmitters. It translates these signals to 1698.65 MHz for transmission to the CDA station.

SVAS: Stretch VAS consists of VAS data processed at the CDA station and retransmitted to the satellite. This SVAS data is received by the satellite and retransmitted to the SVAS receiving stations. It is transmitted at 1687.1 MHz with a bandwidth of 5.0 MHz. It is transmitted for 20 minutes every half hour and shares this time period with VAS data.

WEFAX: The satellite receives narrowband WEFAX (Weather Facsimile) signal from the CDA station, amplifies and downconverts the signal for subsequent

retransmission at 1691 MHz. Function transmitted 10 minutes every half hour and only when the ranging function not used. WEFAX is transmitted to the WEFAX receiving stations.

3.1.2 Low Earth Orbit Satellites

The NOAA satellites operate in polar orbits and carry several instrument systems that provide direct readout and remote recording of meteorological data. Each spacecraft has two VHF and three L-Band frequencies. In general, the spacecraft are capable of downlink transmission of Tiros Information Processor (TIP) data, High Resolution Picture Transmission (HRPT), Automatic Picture Transmission (APT), Global Area Coverage (GAC), Limited Area Coverage (LAC), High speed dump of TIP data and a Data Collection System (DCS).

The three L-Band frequencies provide for four data transmissions; HRPT, GAC, LAC, and stored TIP. There is a separate transmitter and antenna for each L-Band channel (1698, 1702.5, and 1707 MHz). The center frequency transmission is left hand circularly polarized, the other two are right hand circularly polarized. One right hand circularly polarized link is used to continuously transmit the HRPT data unless a failure occurs. The NOAA-11 and 9 satellites are transmitting HRPT data on 1707 MHz. The NOAA-10 satellite is transmitting HRPT data on 1698 MHz.

The satellites transmit different data to small and large receiving terminals. The small L-Band stations (HRPT) receive only HRPT data. The large terminals (CDA) at Wallops Island and Fairbanks receive all of the data.

The TIROS transmissions to various receiving stations are defined in Table 3.

TABLE 3

TIROS SATELLITE TRANSMISSION CHARACTERISTICS

FUNCTION	FREQ-MHz	BAND WIDTH	RECEIVING STATION
STORED TIP	1698/1702.5/1707	1.5 MHZ	CDA
STORED GAC	1698/1702.5/1707	6.0 MHZ	CDA
STORED LAC	1698/1702.5/1707	6.0 MHZ	CDA
HRPT	1698/1707	3.0 MHZ	CDA/HRPT

3.2 Receiving Terminals

3.2.1 Geosynchronous Satellite Receiving Terminals

Three classes of terminals receive the L Band signals transmitted by the GOES satellites; CDA, SVAS AND WEFAX.

The CDA terminal is located at Wallops Island. It is the primary terrestrial interface to the GOES satellites. It receives raw mission data transmissions and spacecraft telemetry. It sends processed mission data for retransmission by the satellite along with satellite commands. Figure 2 shows the spectrum plan for the signals that are received by this station. The Ranging signal is center at 1687.1 MHz. The VAS signal is centered at 1681.6 MHz. The Ranging signal has a bandwidth of 8.2 MHz. The VAS signal has a bandwidth of 23.2 MHz. Ranging and VAS are not transmitted at the same time. The Telemetry signal is centered at 1694.0 and has a bandwidth of 100 kHz. The DCP signal is centered at 1694.5 MHz and has a bandwidth of 400 kHz.

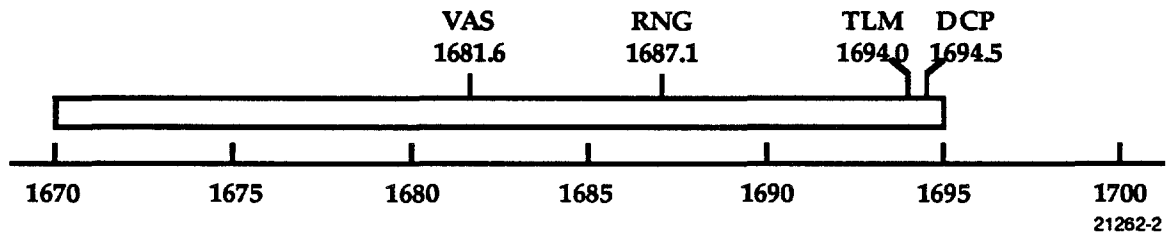


Figure 2. CDA Terminal Spectrum Plan

The Stretch VAS (SVAS) stations receive the processed VAS data. It is estimated that there will be on the order of 50 - 100 of these stations in Region 2. Figure 3 shows the spectrum plan for the signals that are received by this station. This station receives the SVAS signal centered at 1687.1 MHz with a bandwidth of 5.0 MHz. The geographic location of each of these station is presumed to be known.

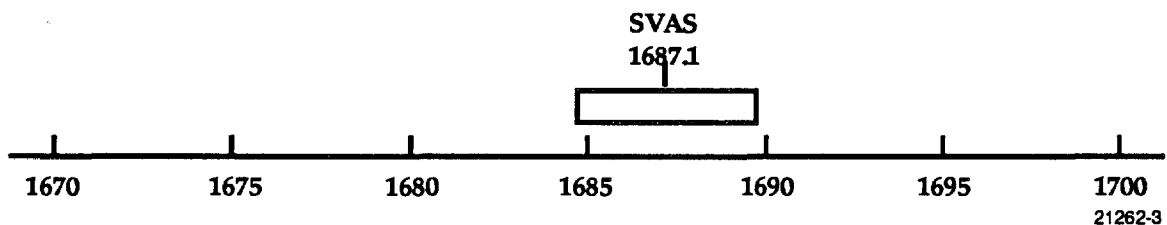


Figure 3. SVAS Terminal Spectrum Plan

The WEFAX stations receive the weather faximile data. There will be thousands of these stations and there locations will not necessarily be known. These stations receive the WEFAX signals at 1691.0 MHz that have a bandwidth of 200 kHz. Figure 4 shows the spectrum plan for this station.

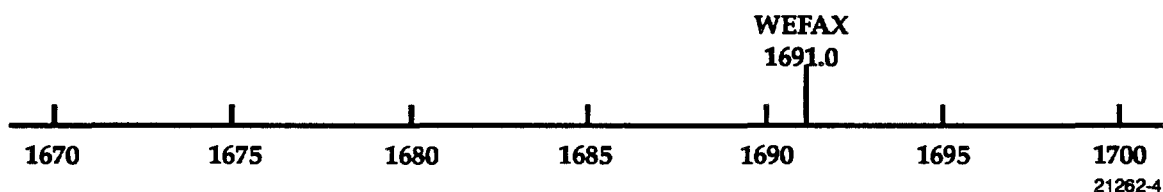


Figure 4. WEFAX Terminal Spectrum Plan

Table 4 summarizes the characteristics of these Terminals.

TABLE 4

GSO SATELLITE RECEIVING TERMINAL CHARACTERISTICS

STATION	NUMBER OF TERM.	FREQUENCY BAND - MHz	ANTENNA DIA - MET.	INTERFERENCE LEVEL - dBW
CDA	1	1670-1700	26	-153
SVAS	50-100	1684.6-1689.6	5 (MAX)	-153
WEFAX	THOUSANDS	1690.9-1691.1	1-2	-153

The Interference level shown is at the antenna input and is very conservative estimate. Further information is needed in this area.

3.2.2 Low Earth Orbit Satellite Receiving Terminals

Two classes of terminals receive the L Band signals from the LEO-METSAT satellites, The CDA and the HRPT terminals.

The spectrum plan for the CDA terminal is shown in Figure 5. Generally, one of the carriers will be used for transmission of HRPT data and the other two will be used for transmission of recorded data. The transmission cover the band from 1695 to 1710 MHz in almost a continuous manner.

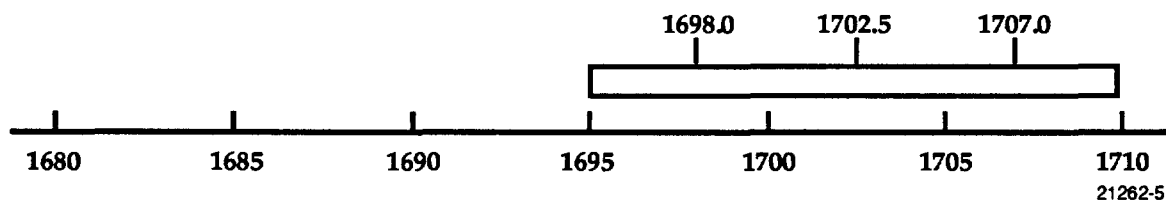


Figure 5. CDA Terminal Spectrum Plan

The spectrum for the HRPT terminal consists of two carriers centered at 1698.0 and 1707.0 MHz, each with a bandwidth of 3 MHz. The spectrum plan for the HRPT terminal is shown in Figure 6.

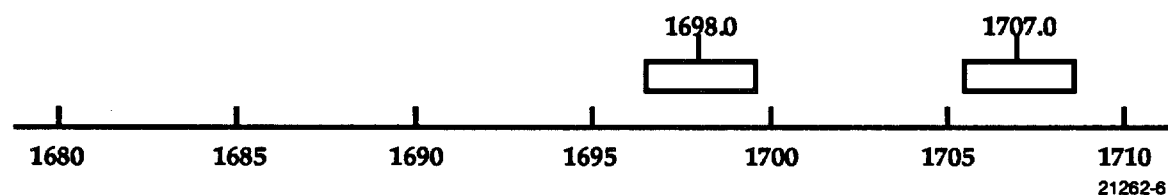


Figure 6. HRPT Terminal Spectrum Plan

The characteristics of these receiving terminals are shown in Table 5. These characteristics are taken from CCIR Report 1121. Only the characteristics important to sharing are included. The Interference levels shown are at the receiver input. They were taken from CCIR report 1121.

TABLE 5

LEO SATELLITE RECEIVING TERMINAL CHARACTERISTICS

STATION	NUMBER OF TERM.	FREQUENCY BAND - MHz	ANTENNA DIA - MET.	ALLOWABLE INTERFERENCE LEVEL - dBW
CDA	2	1695 - 1710	26/12	-124
HRPT	100?	1696.5 - 1699.5 1705.5 - 1708.5	1	-147

4. METAID SERVICE

This section describes the METAID system and provides a summary of the characteristics of its components.

4.1 Description

The METAID system consists of airborne transmitters (radiosondes) and terrestrial receiving terminals (radio theodolites).

A radiosonde and its associated tracking and receiving station are used in the Meteorological-Aids Service for the determination of atmospheric conditions (temperatures, humidity, pressure and wind velocity).

A radiosonde is generally a balloon-borne meteorological instrument which automatically transmits to a ground station such information as barometric pressure, temperature, and humidity information from altitudes up to 30 km (100,000 feet). As the radiosonde is being carried aloft by the balloon, it can travel horizontal distances of more than 160 km (100 miles), depending upon the prevailing wind conditions. The total time of a radiosonde transmission is approximately two hours (determined by life span of the power supply) and there are normally two missions per day per receiving terminal. The maximum number of missions from a receiving terminal in a single day is six or seven.

Radiosonde transmitters use relatively simple technologies, in respect to the design of the modulation system, the temperature compensation of frequency determining components and the initial RF carrier setting. These factors can considerably increase the frequency range occupied by a series of radiosondes, and may be a multiple of the useful signal bandwidth. Approximately 100,000 radiosondes are used worldwide each year.

The NWS, part of the National Oceanic and Atmospheric Administration (NOAA), operates a network of radiosonde launching stations in the United States and its Possessions. Stations are generally located approximately on a 450 km grid across 48 states. There are on the order of 100 such stations in the United States.

The majority of the radiosonde sites in the U.S. operate in the 1660 - 1700 MHz band. In Europe the 403 MHz band is more popular. All major missile launch facilities utilize radiosonde data collection equipment.

For those radiosondes equipped to perform beacon style ranging, 403 MHz is used as the uplink and 1680 MHz as the return downlink. Ranging makes use of a two tone course-fine system.

4.2 Characteristics

The METAID system utilizes both the 403 MHz and the 1660 - 1700 MHz (L-Band) frequencies. The following is a summary of the generic L-Band characteristics for the equipment that is being used for this service. The data

was derived from information supplied by the manufacturers of the equipment.

4.2.1 Generic Transmitter (Radiosonde) characteristics

Frequency Band: 1670 - 1700 MHz

Transmitter power: 300 to 500 mW

Transmitter Antenna: 1/2 wave center fed dipole, linear polarization

Transmitter Frequency Stability: +/- 1 MHz nominal, +/- 4 Mhz maximum

Modulation: FM or Pulsed CW, depending on the unit type

FM Deviation: 100 to 150 KHz, depending upon radiosonde type

FM Modulation Index: 2

Bandwidth: Approximately 500 KHz

4.2.2 Typical Receiving System (Radio Theodolite) Characteristics

Frequency: 1670 - 1700 MHz

Receiver Noise Figure: 2 to 3 dB

RF Bandwidth: 40 MHz

IF Predetection Bandwidth: 1 MHz

Antenna System: 8 to 9 foot steerable Parabolic dish

Antenna Gain: 28 dBi

Antenna Beamwidth: 5 degrees

4.2.3 Balloon Flight Parameters:

Ascention: 90 minutes to 110,000 foot altitude

Parachute return: 30 to 50 minutes

Number of balloon releases: Typically 2 per day per station

4.2.4 Future Trends:

New modulation format: PCM at 256 Kbps

New information: GPS position

Use: Current radiosonde use is world wide. 5 year phaseout planning has been going on for the last 30 years with little impact on the program.

5. SHARING

This section describes the method to be used for sharing of the spectrum with each of these systems. As shown in Figure 1 Each of the services occupy different portions of the frequency band. These are summarized as follows:

MSS:	1675 - 1710 MHz
METAIDS:	1660 - 1700 MHz
GSO-METSAT:	1670 - 1698 MHz
LEO-METSAT:	1698 - 1710 MHz

For example, in the frequency band, 1700 - 1710 MHz, the MSS need only share with the LEO-METSAT service.

5.1 METSAT Service

The potential for sharing of spectrum is evaluated below for the LEO-MSS Earth terminals and METSAT receiving stations and the METSAT satellites with the LEO-MSS satellites.

5.1.1 LEO-MSS Earth terminals interfering with the METSAT receiving terminals

Sharing of the spectrum is postulated by the establishment of a "protection zone" around the METSAT receiving terminals. MSS Earth terminals are precluded from transmitting from within the "protection zone" on frequencies that would cause harmful interference.

The WEFAX terminals would not have protection zones. There are simply too many and their location may not be known. The 200 kHz band centered on 1691.0 MHz would not be used by the MSS terminals.

The LEO-MSS systems must store the location and characteristics of the METSAT receiving stations and operate in a manner that will not cause harmful interference. This appears possible for LEO-MSS systems that are technically sophisticated and are willing to take the steps necessary to accomplish this sharing.

These steps include:

- A. Establishing a data base on information regarding the the METSAT system by the MSS-LEO system.
 1. Location and characteristics of the METSAT receiving earth terminals.
 2. Orbital parameters, frequencies and transmission parameters of the LEO-METSATS

3. Orbital location, frequencies and transmission parameters of the GSO-METSATS
 4. Interference radius around each receiving METSAT earth terminal. This is the radius within which a LEO-MSS transmitter may not transmit in-band. This must be individualized for each METSAT receiving Earth terminal and each each type of LEO-MSS Earth terminal. For LEO-METSAT terminals, there must be an interference radius for both main-beam and sidelobe reception of the interfering signal.
- B. Operational procedures to insure that no LEO-MSS terminal will transmit in-band when inside of the interference radius of the nearby METSAT receiving earth terminals.
1. Before assigning a transmission frequency for a LEO-MSS Earth terminal, utilize its RDSS position location to determine its position relative to the nearest METSAT receiving terminals
 2. Determine the type, frequency of operation, and interference radius (or radii) for the nearby METSAT terminal(s).
 3. Determine the applicable interference radius for GSO-METSAT terminals; (GSO-METSAT terminals have only one, side-lobe.)
 4. Determine the applicable interference radius for LEO-METSAT terminals; (LEO-METSAT terminals have two, main-beam and side-lobe)
 - a. Determine the visibility time of the LEO-METSAT based on its orbital parameters. Each LEO-METSAT will be visible to a METSAT earth terminal satellite for only about 10 minutes every 100 minutes, or 10 % of the time. If the LEO-METSAT is not visible, the interference radius is zero and any frequency may be assigned (which will be about 90 % of the time).
 - b. If the LEO-METSAT is visible (or soon will be), determine from the orbital parameters of the satellite and the relative positions of the METSAT and LEO-MSS terminals if the LEO-MSS terminal will be in the main beam of the METSAT receiving antenna at any time during the orbital pass. If it will not be, then the sidelobe interference radius may be used. On average the LEO-MSS terminal will be in the main-beam only about 3% of the time.
 4. From the above, select the operating frequency

5.1.2 Determination of the Interference Radius

5.1.2.1 Path Loss

The path loss between the transmitter and the receiver may be estimated by an extension of the equations developed by Okumura et al. The analysis was performed for urban and suburban locations. An elevation of 10 meters was assumed for the METSAT receiving antenna and 2 meters for the LEO-MSS terminal. It should be noted that these calculations are representative and that calculations may be made for each specific METSAT terminal location.

5.1.2.2 Protection Zone Calculations

The following Tables show examples of the protection zones for each LEO-MSS satellite systems considered and each type of METSAT receiving terminal.

Table 5 calculates the protection zone for the three GOES receiving stations. The CDA station at Wallops island is assumed to be in a rural area. The SVAS station is calculated for both urban and suburban areas.

TABLE 5
GSO SATELLITE EARTH TERMINALS

STATION LOCATION	CDA RURAL	SVAS URBAN	SVAS SUBURBAN
SATELLITE SYSTEM	PROTECTION ZONE - KM		
ELLIPSO II	35	5	10
GLOBALSTAR B	21	3	6
ODYSSEY	14	2	4
ARIES	21	3	6

Table 6 shows the protection zone for the LEO satellites and the CDA terminal.

TABLE 6
LEO SATELLITE/ CDA TERMINAL

SATELLITE SYSTEM	PROTECTION ZONE - KM	
	MAIN BEAM	SIDELOBE
ELLIPSO II	98	32
GLOBALSTAR B	60	18
ODYSSEY	49	14
ARIES	60	18

Table 7 shows the protection zone for the LEO satellites and the small Earth terminals.

TABLE 7
LEO SATELLITE/SMALL EARTH TERMINALS

SATELLITE SYSTEM	PROTECTION ZONE - KM			
	SIDE LOBE		MAIN BEAM	
	URBAN	SUBURBAN	URBAN	SUBURBAN
ELLIPSO II	7.0	14.0	22.0	44.0
GLOBALSTAR B	4.0	8.5	13.0	26.0
ODYSSEY	3.0	6.0	9.5	18.0
ARIES	4.0	8.5	13.0	26.0

5.1.3 METSAT satellites interfering with LEO-MSS satellites

The METSAT satellites transmit at L-Band in the space-to-Earth direction. The receiver of a LEO-MSS satellite may be in the beam of this satellite. The interference must be calculated for each system, however some generalities may be made.

The interference from a GSO METSAT generally should not be a problem since its transmissions will generally enter the backlobes of the LEO-MSS antenna patterns. There may be occasions when it is not and in those cases ;frequency diversity may have to be used.

The interference from a LEO METSAT could be more of a problem since, for certain systems, the satellites may pass in proximity to each other. Again, frequency diversity may have to be used in these situations.

5.1.4 Conclusions

The sharing scenario described in the preceding paragraphs provides Earth terminals in the METSAT service protection from harmful interference by Earth terminals in the MSS service. Thus spectrum sharing should be possible by METSAT and LEO-MSS systems that possess the technical sophistication to participate in the sharing scenarios.

5.2 METAID SERVICE

5.2.1 LEO-MSS Earth terminals interfering with the METAID receiving terminals

As was done with the METSAT service, sharing of the spectrum is postulated by the establishment of a "protection zone" around the METAID receiving terminals. MSS Earth terminals are precluded from transmitting from within the "protection zone" on frequencies that would cause harmful interference.

As was done with the METSAT service, the LEO-MSS systems must store the location and characteristics of the METAID receiving stations and operate in a manner that will not cause harmful interference

The following are the steps necessary to accomplish this sharing:

- A. Establishing a data base on information regarding the the METAID system by the MSS-LEO system.
 1. Location and characteristics of the METAID receiving terminals.
 2. Interference radius around each receiving METAID receiving terminal. This is the radius within which a LEO-MSS transmitter may not transmit in-band. This must be individualized for each METSAT receiving terminal and each each type of LEO-MSS Earth terminal.
- B. Operational procedures to insure that no LEO-MSS terminal will transmit in-band when inside of the interference radius of the nearby METAID receiving terminals.
 1. Before assigning a transmission frequency for a LEO-MSS Earth terminal, utilize its RDSS position location to determine its position relative to the nearest METAID receiving terminal(s)
 2. Determine the type, frequency of operation, and interference radius (or radii) for the nearby METAID terminal(s).
 3. Determine the applicable interference radius for METAID receiving terminals.
 4. From the above, select the operating frequency

5.2.2 Determination of the Interference Radius

5.2.2.1 Path Loss

The path loss between the transmitter and the receiver may be estimated by an extension of the equations developed by Okumura et al. The analysis was performed for urban and suburban locations. An elevation of 10 meters was assumed for the METAID receiving antenna and 2 meters for the LEO-MSS terminal. It should be noted that these calculations are representative and that calculations may be made for each specific METAID terminal location.

5.2.2.2 Protection Zone Calculations

Table 2 shows examples of the protection zones for each of the LEO-MSS satellite systems considered.

TABLE 2 - METAID PROTECTION ZONES - KM

SATELLITE SYSTEM	URBAN	SUBURBAN
ELLIPSO II	5.0	11.0
GLOBALSTAR B	3.0	6.3
ODYSSEY	2.0	4.0
ARIES	3.5	7.7

The protection zones are calculated for side-lobe entry of the interfering signals only. The only time the interfering signal could enter the main lobe is during launch. This is also the time that radiosonde is in close proximity to the receiving terminal and the received METAID signal is very strong. Under these conditions, the interference from the LEO-MSS at the indicated protection zone radius is negligible.

Considering that the NWS stations are on approximately 450 Km grid in the United States, the area covered by the protection zones is probably less than 0.01% of the area in the United States.

5.2.3 METSAT Radiosondes interfering with LEO-MSS satellites

As the balloon ascends with the radiosonde, it is transmitting a signal that is in the receive frequency band of the LEO-MSS satellites. The interference from the radiosondes must be calculated for each system.

Table 3 calculates the interference power for each satellite system and shows the margin over the acceptable interference power.

TABLE 3

RADIOSONDE INTERFERENCE INTO LEO-MSS SATELLITES

SATELLITE SYSTEM	INTERFERENCE MARGIN - dB
ELLIPSO II	8.8
GLOBALSTAR B	10.2
ODYSSEY	3.6
ARIES	18.8

Table 4 shows that the radiosondes should not interfere with a properly designed system. The systems shown have all indicated that they can co-exist with each other the same band so they should be able to share with the radiosonde signals. The radiosonde signals are low compared with the levels to which these systems have claimed they can co-exist.

5.2.4. Conclusions

The sharing scenario described in the preceding paragraphs provides receiving terminals in the METAIDS service protection from harmful interference by Earth terminals in the MSS service. The sharing scenario also shows that the radiosondes will not provide harmful interference into the LEO-MSS satellites. Thus spectrum sharing should be possible for LEO-MSS systems that include an RDSS capability and possess the technical sophistication to participate in the sharing scenarios and the METAID service.

It should be noted that since the upper frequency limit of the METAID service is 1700 MHz, the band from 1700 to 1710 may be used by the LEO-MSS systems without a sharing arrangement for the METAID service.

6. SUMMARY AND CONCLUSIONS

This study shows that sharing is possible between Low Earth Orbit Mobile Satellite Service (LEO-MSS) and the Meteorological Satellite Service (METSAT) and Meteorological Aids Service (METAID).

Sharing of the spectrum is postulated by the establishment of a "protection zone" around the METSAT and METAID receiving terminals. MSS Earth terminals are precluded from transmitting from within the "protection zone" on frequencies that would cause harmful interference.

The locations and characteristics of the METSAT and METAID terminals are known. The MSS terminals are relatively few in number and have a position location capability. When an MSS terminal is in the vicinity of a METSAT or METAID terminal, it, or the MSS system central control, will determine its type, frequency and time of operation, protection zone area, and assign or use frequencies that will not cause harmful interference to the terminal.

One class of METSAT terminal, the WEFAX (WEather FAXimile) terminals, would not have protection zones. There are simply too many and their location may not be known. The 200 kHz band centered on 1691.0 MHz would not be used by the MSS terminals. Considering that the MSS band allocation is 35 MHz, a 200 khz exclusion is very small.

An important sharing criteria is not to constrain the development of the METSAT and METAID services. Since the LEO-MSS systems have communication with central control, any changes to the METSAT or METAID systems may be coordinated so as not to cause constraints on system development and still have the usage by the LEO-MSS systems.

CERTIFICATE OF SERVICE

I, Philip L. Malet, hereby certify that the foregoing Petition for Rulemaking was served by first-class mail, postage prepaid, this 22nd day of September, 1992 on the following persons:

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